CHAPTER 3

DEVELOPMENT OF THE AIR TOXICS EMISSIONS INVENTORY

Chapter 3. Development of the Air Toxics Emissions Inventory

3.1 Introduction

An emissions inventory of air pollutants and their sources is essential to identify the major contributors of toxic air contaminants and to develop strategies to improve air quality. We obtain the information necessary to develop a detailed emissions inventory for the Basin from South Coast AQMD data sources as well as from other government agencies including California Air Resources Board (CARB), California Department of Transportation (Caltrans), and Southern California Association of Governments (SCAG).

Each of these agencies is responsible for collecting or generating data (e.g., industry growth factors, socio-economic projections, travel activity levels, emission factors, emission speciation profiles) and developing methodologies (e.g., models, demographic forecasts) that are used to develop a comprehensive emissions inventory. South Coast AQMD is solely responsible for developing the point source inventory while the area source inventory is developed jointly by South Coast AQMD and CARB. CARB is the primary agency responsible for developing the emissions inventory for all mobile sources and provides on-road and off-road mobile source inventories from their on-road emission factor model (EMFAC), and off-road inventory tools, respectively. SCAG is the primary agency for projecting population and economic activity growth in the Basin. Caltrans provides SCAG with highway network, traffic counts, and road capacity data. SCAG incorporates these data into their Travel Demand Model for estimating and projecting vehicle miles traveled (VMT) and vehicle speed. CARB's on-road mobile source inventory also relies on SCAG's VMT estimates.

3.2 Overview

The air toxic emissions inventory for MATES V consists of four components: (1) point sources; (2) area sources; (3) on-road mobile sources; and (4) off-road (or other) mobile sources. Point source emissions are emissions from facilities having one or more pieces of equipment permitted with the South Coast AQMD with total facility-wide emissions above certain threshold levels. Area sources represent numerous small sources of emissions that can collectively have significant emissions (e.g., dry cleaners, retail gasoline stations, auto body shops, residential heating). On-road mobile sources include cars, trucks, buses, and motorcycles. All mobile sources not included in the on-road mobile source inventory are considered "off-road" mobile sources including aircraft, ships, commercial boats, trains, recreational vehicles, construction and industrial equipment.

The 2016 Air Quality Management Plan (AQMP)[1] is the basis for the criteria and air toxics emissions inventory developed for MATES V with additional updates discussed in this chapter. A "top-down" approach is used to develop the toxics inventory; that is, toxic emissions are

[1] Final 2016 Air Quality Management Plan: https://www.aqmd.gov/home/air-quality/clean-air-plans/air-quality-mgt-plan/final-2016-aqmp.

calculated by applying the latest CARB speciation profiles[2] to the total organic gas (TOG) and particulate matter (PM) emissions. Speciation profiles provide estimates of the emission's chemical composition. CARB maintains and updates the chemical composition and size fractions of PM and the chemical composition and reactive fractions of TOG for a variety of emission source categories. The source type (e.g., equipment and fuel) is used to identify the appropriate speciation profile.

A top-down approach is preferable for a regional modeling risk analysis, for the following reasons:

- Speciating the VOC and PM inventory affords consistency with the 2016 AQMP;
- The photochemistry algorithms in the MATES V modeling system require the complete speciation of VOC emissions to ensure their correct application;
- Consistent approach used in the past MATES reports enables comparisons of emission changes over time.

3.3 Point Sources

The point source emissions included in MATES V are emissions reported to South Coast AQMD through the Annual Emissions Reporting (AER) program, which applies to facilities emitting four tons or more of VOC, NOx, SOx, or PM or emitting 100 tons or more of CO per year. Facilities subject to the AER Program calculate and report their emissions primarily based on their throughput data (e.g., fuel usage, material usage), appropriate emissions factors from best available information (such as Continuous Emissions Monitoring, sources tests, permit limits and US EPA AP-42) and control efficiency, if applicable. Under the 2018 AER Program, approximately 1,800 facilities reported their annual emissions to the South Coast AQMD. Emissions from facilities not subject to the AER Program are included as part of the area source inventory (see Section 3.4).

To prepare the point source inventory, emissions from each facility is categorized based on the U.S. EPA's Source Classification Codes (SCCs) for each emission source category. The AER facilities report their annual emissions at the device level (i.e., by SCC). For modeling purposes, the facility location specified in latitude/longitude coordinates is translated into the modeling coordinate system. The business operation activity profile is also recorded so that the annual emissions can be distributed temporally throughout the day, week, and month.

Toxic emissions are calculated by applying the latest CARB speciation profiles to the TOG and particulate matter emissions. The SCC is used to identify the appropriate speciation profile for the source.

3.4 Area Sources

The area source emissions developed for the 2016 AQMP projected from 2012 to the year of

[2] CARB speciation profiles can be viewed or downloaded from the following CARB link: http://www.arb.ca.gov/ei/speciate/speciate.htm

interest (2018) are used for MATES V. The South Coast AQMD and CARB shared the responsibility for developing the 2012 area source emissions inventory for approximately 500 area source categories. For each area source category, a specific methodology is used for estimating emissions. Emissions are spatially allocated to 2 km by 2 km grids using spatial surrogates. Some commonly used spatial surrogates are listed in Table 3-1. For some permitted minor point sources (not reported in the AER program) such as dry cleaners, gasoline dispensing facilities and autobody shops, emissions are allocated to permit locations according to permitted emissions. As with the point source inventory, toxic emissions are calculated by applying the latest CARB speciation profiles to the TOG and particulate matter emissions.

Table 3-1. Commonly Used Spatial Surrogates for Spatial Distributions of Area and Off-Road Sources

Population	Total employment
VMT	Industrial employment
Length of rail per grid cell	Retail employment
Locations of unpaved rural roads	Single dwelling units
Total housing	Rural land cover – forest
Agricultural land cover	Rural land cover – range land
National forest > 5000 ft	

Source: http://eos.arb.ca.gov/eos/projects/surrogates/

3.5 On-Road Mobile Sources

On-road emissions are estimated by combining emission factors with vehicular activity data. For the 2016 AQMP, CARB's EMFAC2014 emission factors were used along with link-based traffic volumes and speeds obtained from the SCAG's regional transportation modeling. Since the 2016 AQMP, EMFAC2017 was released and replaced EMFAC2014, reflecting more recent available vehicle emission factors and regulations.[3] Therefore, emission factors from EMFAC2017 were applied to vehicle activity data used in the 2016 AQMP (based on 2016 RTP) to develop the 2018 on-road emissions for MATES V. The Direct Travel Impact Model (DTIM) was used to link emission factors and the SCAG's transportation modeling results to generate hourly gridded emissions of criteria pollutants (i.e., TOG, NOx, PM, CO, and SOx). The DTIM emissions were adjusted based on the EMFAC2017 values. Environmental variables that affect emission rates (e.g., ambient temperature and humidity) were derived from meteorological modeling. The SCAG's transportation modeling results were for an average weekday. To obtain day-specific on-road emissions, the CalTrans Performance Monitoring System (PeMS) and weigh-in-motion (WIM) data were utilized. Toxic emissions are calculated by applying the latest CARB

[3] EMFAC model and documentation: http://www.arb.ca.gov/msei/modeling.htm

speciation profiles for mobile sources to the TOG and PM emissions. A flow chart illustrating this process is provided in . Some of the key steps in the process are discussed in more detail below.

EMFAC, in its current form, is a suite of computer models that estimates the on-road emissions of hydrocarbons (TOG and HC), CO, NOx, PM, lead (Pb), SO_2, and CO_2 for calendar years 2000 to 2050. EMFAC considers 1965 and newer model year vehicles powered by gasoline, diesel, or electricity and reports for 13 broad vehicle classes as shown in Table 3-2. Over 100 different technology groups are accounted for within each class (e.g., catalyst, non-catalyst, three-way catalyst, carbureted, multiport fuel injection, LEV, TLEV, SULEV).

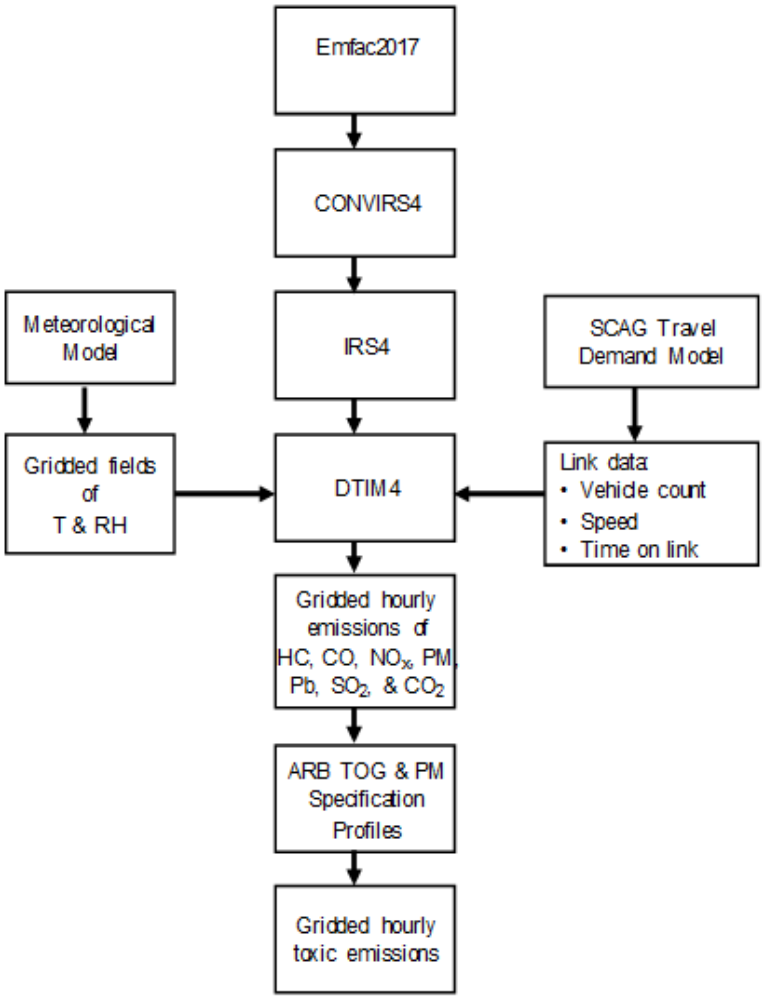

Figure 3-1. Flow Diagram for On-Road Emissions Processing.

Table 3-2. Broad Vehicle Classes Considered by EMFAC.

Vehicle Class	Weight (lbs)
Passenger cars	All
Light Truck I	0 – 3,750
Light Truck II	3,751 – 5,750
Medium-Duty Truck	5,751 – 8,500
Light-Heavy-Duty Truck I	8,501 – 10,000
Light-Heavy-Duty Truck II	10,001 – 14,000
Medium-Heavy-Duty Truck	14,001 – 33,000
Heavy-Heavy-Duty Truck	33,001 – 60,000
Motorcycle	All
Urban Diesel Bus	All
School Bus	All
Other bus	All
Motor Homes	All

Source: Adopted from the User's Guide for EMFAC2017.

EMFAC currently considers the following county-specific information when calculating emissions:

- Ambient air temperature (denoted by T in Figure 3-1);
- Relative humidity (denoted by RH in Figure 3-1);
- Vehicle population;
- Fleet composition;
- Fleet growth rates;
- Mileage accrual rates;
- Vehicle age distribution;
- Distribution of VMT by speed;
- Smog check regulations;
- Fuel properties; and
- Altitude.

Selected on-road activity information for the four counties in the Basin is summarized in Table 3-3. Four of the top seven counties in California in terms of vehicle population, VMT, and vehicle trips are within the South Coast AQMD jurisdiction.

Table 3-3. Vehicle Activity Information for the Counties in the Basin.

County	Vehicle Population	VMT/day	Trips/day	Miles per Vehicle-Day
Los Angeles	5,678,851	223,446,000	27,863,372	39.3
Orange	2,077,140	81,369,000	10,167,130	39.2
Riverside	1,186,800	49,847,000	5,997,085	42.0
San Bernardino	1,021,318	43,021,000	5,150,475	42.1

Source: EMFAC2017 and SCAG 2016 RTP

One of the EMFAC outputs summarizes TOG, CO, NOx, PM, lead, SO_2, and CO_2 emission rates for a given calendar year for each vehicle class and for each county/air basin specified. The DTIM modeling system is used in conjunction with EMFAC emission rates to prepare gridded hourly on-road emissions for photochemical grid modeling. EMFAC provides emissions rates by vehicle category, fuel type and fleet average vehicle model year.

The DTIM processing system consists of three Fortran program modules: CONVIRS4, IRS4, and DTIM4. The main function of CONVIRS4 is to re-format the emission rate file output from EMFAC into a form compatible with IRS4. IRS4 creates fleet average emission rates by ambient air temperature, relative humidity, and vehicle speed.

The DTIM4 module prepares gridded, hourly on-road emissions of TOG, CO, NO_X, PM, SO_2, and CO_2 link by link in the transportation network. SCAG's Travel Demand Model provides the following for each link in the transportation network: the number of vehicles, their average speed, and time on the link. Separate files containing hourly gridded temperature (T in Figure 3-1) and relative humidity (RH in Figure 3-1) are provided as input to DTIM4. Knowing the air temperature and relative humidity representative of the link and the average vehicle speed on the link, DTIM4 looks up the fleet average emission rate in the file prepared by IRS4 and multiplies these by the number of vehicles and the average time on the link.

Finally, CARB speciation profiles[4] are used to speciate the on-road TOG and PM emissions into its toxic components.

3.6 Off-Road Mobile Sources

The 2016 AQMP off-road emissions projected for 2018 were used for MATES V. CARB developed and updated the methods to estimate emissions from each off-road source category[5] except for aircraft, which South Coast AQMD developed. For the 2016 AQMP, CARB's off-road emissions tools were used to estimate emissions for all off-road categories (100+ source categories). These emissions tools incorporate various aspects of off-road elements, such as the effects of various adopted regulations, technology types, and seasonal conditions on emissions.

[4] CARB speciation profiles can be viewed or downloaded from the following CARB link: http://www.arb.ca.gov/ei/speciate/speciate.htm

[5] The OFF-ROAD Model tools and its documentation can be obtained at the following CARB link: https://ww2.arb.ca.gov/our-work/programs/mobile-source-emissions-inventory/msei-road-documentation-0

The tools combine population, activity, horsepower, load factors, and emission factors to yield the annual equipment emissions by county, air basin, or state. Spatial and temporal features are incorporated to estimate seasonal emissions. Emissions for ocean-going vessels (OGV) and commercial harbor craft (CHC) were developed by CARB for the 2016 AQMP. Subsequent to the 2016 AQMP, CARB updated the OGV inventory and submitted it to the US EPA as part of its SIP updates.[6] This version of the OGV inventory was used in MATES V. The rest of the off-road mobile emissions are from the 2016 AQMP emissions inventory. Countywide off-road emissions are spatially allocated to 2 km by 2 km grids using spatial surrogates while aircraft emissions are allocated to the respective airports. Toxic emissions are calculated by applying the latest CARB speciation profiles for off-road mobile sources to the hydrocarbon and particulate matter emissions.

3.7 Summary of Air Toxic Emissions

Table 3-4 presents the emissions of selected compounds apportioned by the on-road, off-road, point, and area source categories. Chemicals that are considered potential or known human carcinogens are denoted with a check mark. Toxic emissions by major source categories are provided in Appendix VIII.

Table 3-4. 2018 Annual Average Day Toxic Emissions for the South Coast Air Basin.

	Pollutant	Emissions (lbs/day)				
	VOC Species	On-road	Off-road	Point	Area	Total
√	Acetaldehyde*	2,575.1	2,449.2	91.4	1,653.1	6,768.8
	Acetone**	2,268.2	1,695.8	400.3	25,900.9	30,265.1
√	Benzene	4,662.6	4,156.2	634.2	1,392.3	10,845.3
√	1,3-Butadiene	546.9	986.1	142.9	42.0	1,717.8
√	Carbon tetrachloride	0.0	0.0	10.4	0.1	10.6
√	Chloroform	0.0	0.0	54.3	0.9	55.2
√	1,1 Dichloroethane	0.0	0.0	2.3	68.1	70.4
√	1,4 Dioxane	0.0	0.0	0.2	0.0	0.2
√	Ethylene dibromide	0.0	0.0	0.2	0.0	0.2
√	Ethylene dichloride	0.0	0.0	84.2	11.9	96.1
√	Ethylene oxide	0.0	0.0	3.7	0.0	3.7
√	Formaldehyde*	5,249.2	6,222.9	1,597.4	4,320.3	17,389.8
	Methyl ethyl ketone*	445.6	296.9	366.8	5,676.5	6,785.7
√	Methylene chloride	0.0	0.0	1,016.0	11,687.0	12,703.0
√	MTBE	206.1	0.8	0.0	0.0	206.9
√	Naphthalene	206.8	185.4	30.4	118.8	541.5
√	p-Dichlorobenzene	0.0	0.0	114.9	2,185.3	2,300.2
√	Perchloroethylene	0.0	0.0	1,079.2	2,145.1	3,224.3
√	Propylene oxide	0.0	0.0	0.5	0.3	0.8

[6] CARB 2018 SIP Update can be viewed or download from the following CARB link: https://ww2.arb.ca.gov/resources/documents/2018-updates-california-state-implementation-plan-2018-sip-update

	Styrene	242.0	165.5	801.8	3,853.7	5,063.0
	Toluene	10,970.5	8,078.3	3,238.8	19,671.2	41,958.8
√	Trichloroethylene	0.0	0.0	656.7	498.1	1,154.8
√	Vinyl chloride	0.0	0.0	178.7	1,103.4	1,282.1
	PM Species					
√	Arsenic	0.4	1.8	5.3	6.5	14.0
√	Cadmium	0.1	0.3	4.3	7.7	12.5
	Chromium	46.7	5.0	15.3	30.9	97.9
√	Diesel particulate	4,210.6	5,213.0	218.9	66.7	9,709.2
	Elemental carbon***	4,003.9	4,019.1	946.6	6,739.7	15,709.3
√	Hexavalent chromium	0.5	0.3	0.1	0.0	0.8
√	Lead	4.0	9.6	5.9	98.9	118.4
√	Nickel	24.6	8.2	27.6	19.5	79.9
	Organic carbon	9,479.2	6,030.4	4,462.7	45,715.6	65,687.9
	Selenium	0.9	0.2	0.6	2.4	4.1
	Silicon**	2,535.3	121.3	2,665.6	101,422.4	106,744.5

√ Denotes potential or known human carcinogen.
* Primarily emitted emissions. These materials are also formed in the atmosphere from photochemical reactions.
** Acetone and silicon are not toxic compounds. Their emissions are included here because they were measured in the sampling program.
*** Includes elemental carbon from all sources (including diesel particulate).

Species and source apportionment data are shown in Table 3-5 and , respectively. In those illustrations, the emissions of the carcinogenic pollutants in Table 3-4 are weighted by the ratio of their inhalation cancer potency to the cancer potency of diesel PM (DPM). Thus, emissions from species less potent than DPM (e.g, benzene, perchloroethylene) are weighted less, while emissions from species more potent than DPM (e.g., hexavalent chromium, arsenic) are weighed more. DPM has a weighting factor of one.

Table 3-5. Cancer Potency Weighted Species Apportionment for 2018 Emissions

Toxic	Contribution (%)	Toxic	Contribution (%)
Diesel particulate	72.52	Methylene chloride	0.30
Benzene	7.36	Trichloroethylene	0.05
1,3-butadiene	7.00	Lead	0.03
Hexavalent chromium	2.92	Ethylene dichloride	0.04
Formaldehyde	2.48	Ethylene oxide	<0.01
Vinyl chloride	2.35	Carbon tetrachloride	<0.01
Cadmium	1.21	1,1-Dichloroethane	<0.01
Arsenic	1.14	MTBE	<0.01
p-dichlorobenzene	0.62	Ethylene dibromide	<0.001
Nickel	0.49	Chloroform	<0.01
Acetaldehyde	0.46	Propylene oxide	<0.0001
Perchloroethylene	0.46	1,4-Dioxane	<0.0001
Naphthalene	0.44		

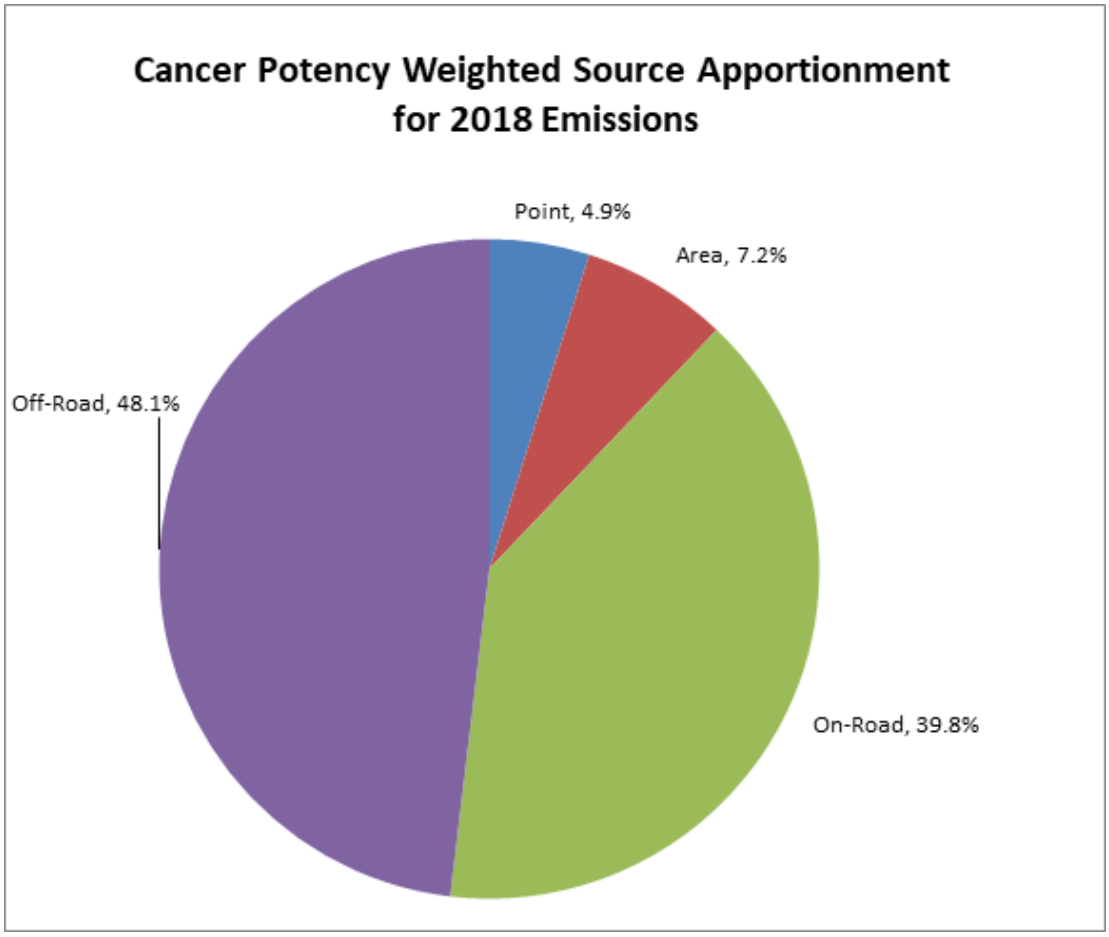

Figure 3-2. Cancer Potency Weighted Source Apportionment for 2018 Emissions.

Taking cancer potency into consideration, DPM account for about 72% of the overall carcinogenic air toxics emissions (Table 3-5). Model predicted cancer risks are discussed in Chapter 4. The other significant compounds (i.e., contributions >1%) are 1,3-butadiene, benzene, hexavalent chromium, formaldehyde, vinyl chloride, arsenic and cadmium. On-road and off-road mobile sources account for nearly 88% of the total weighted carcinogenic air toxics emissions and stationary (i.e., point and area) sources contribute about 12% (Figure 3-2). Compared to the past MATES reports where the on-road category was the biggest contributor the carcinogenic air toxics emissions in the air toxics inventory (e.g., 50.7% in MATES IV), MATES V shows that the off-road category is now the highest contributor at 48.1% with the on-road category at 39.8%.

Carcinogenic emissions have been continuously decreasing over the last several decades due to existing regulations and control programs and adoption of cleaner technologies. Compared to MATES IV, emissions of carcinogenic pollutants have decreased by 48% in MATES V. As shown in Figure 3-3, carcinogenic emissions from on-road mobile, off-road mobile and point source categories decreased by 59%, 39%, and 49%, respectively. These reductions primarily are attributable to programs and regulations by South Coast AQMD and CARB. Carcinogenic emissions from area source category increased by 20%. This increase in toxics emissions in area sources is due to changes in assignment of speciation profiles in two area source categories -

'plastics and plastic product manufacturing' and 'coatings and related processes'. The former, which did not have any gaseous toxics emissions in the MATES IV modeling platform, used an industry specific profile that yielded 235 lbs/day DPM equivalent toxics emissions from vinyl chloride in the MATES V modeling. Similarly, the latter category, which did not have particle phase toxics emissions during the MATES IV modeling, yielded 53 lbs/day DPM equivalent toxics emissions from cadmium due to changes in speciation profiles. Without these updates in speciation profile assignments, toxics emissions from the area source category would have decreased by 16% from MATES IV to MATES V. Methylene chloride emissions increased from 9,900 lbs/day (31.5 lbs/day DPM equivalent) in MATES IV to 12,703 lbs/day (40.4 lbs/day DPM equivalent) in MATES V. This increase was due to: 1) increase in area sources TOG emissions from MATES IV to MATES V, for example, a category of area source degreasing (sealant and caulking) TOG emissions increased from 2.77 tons/day to 3.39 tons/day, resulting in 1,241 lbs/day increase in methylene chloride emissions: 2) a change in speciation profile used for consumer products/paint remover (methylene chloride content increased from 51% to 66%) resulted in 1,008 lbs/day more and 3) there were 989 lbs/day more from MATES V point sources due to changing in assignments of SCC codes to emissions.

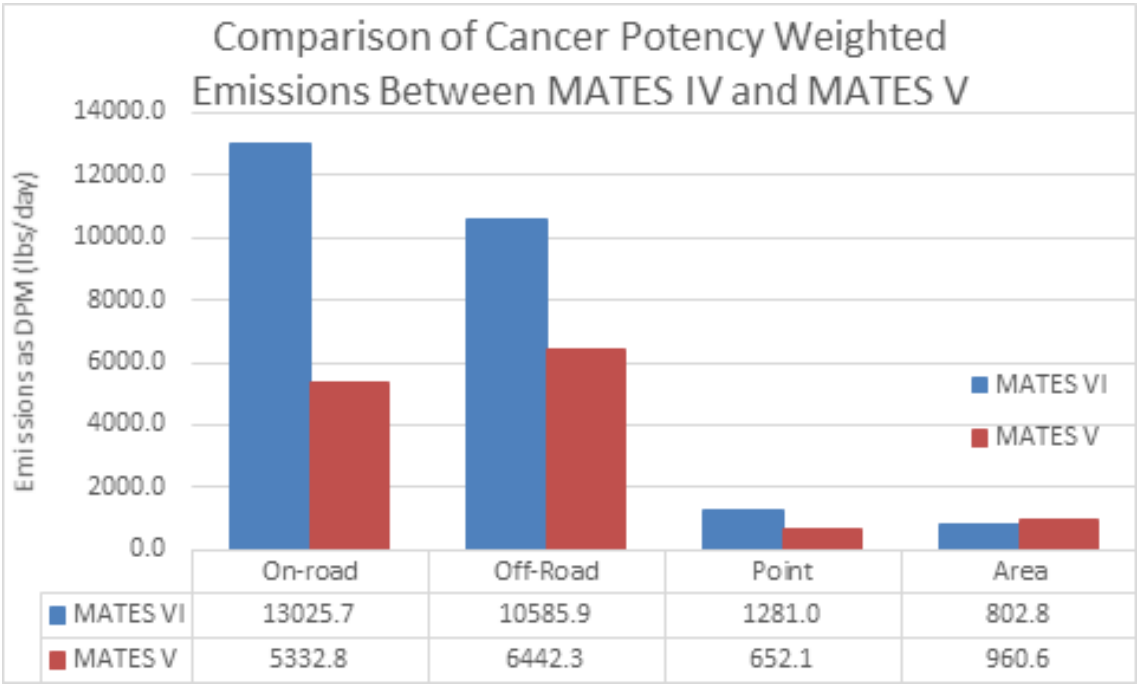

Figure 3-3. Comparison of Cancer Potency Weighted Emissions between MATES IV and MATESV.

3.8 Emissions and Air Quality Changes for Select Air Toxics Since MATES IV

Table 3-6 compares the emissions and the measured air quality changes since MATES IV for selected air toxics. The air quality change was quantified as the difference of measured annual average ambient concentrations from the MATES IV to the MATES V periods. For gaseous species, measurements from the following stations were evaluated: Burbank Area, Compton,

Huntington Park, Inland Valley San Bernardino, Long Beach, Pico Rivera and West Long Beach. For toxic metals and EC, data from all ten monitoring sites were used. As shown in the table, emissions of elemental carbon have decreased by 56%, and measured concentrations have reduced by 45% since MATES IV. Comparisons of some other species are more complicated due to atmospheric chemistry and transport.

Several caveats are important to consider when comparing the changes in emissions inventory and ambient measurements. For example, weather and dispersion of pollutants can influence the relationship between emissions and ambient concentrations. Also, the inventory is a regional estimate of total emissions throughout the Basin, whereas ambient measurements are from the ten fixed monitoring locations where there may be influences from local sources. Another difference is that secondary formation and degradation of substances in the atmosphere are not accounted for in the emissions comparisons but are captured in the ambient measurements. In particular, current MATES V modeling results showed that formaldehyde and acetaldehyde came from secondary formation rather than direct emissions during the MATES V period.

Table 3-6. Emissions and Air Quality Changes for Select Air Toxics Since MATES IV.

Pollutant	Change in Emissions	Change in Monitored Concentration
Gases		
Acetaldehyde	+2%	+62%
Benzene	-10%	-27%
1,3-butadiene	-33%	-36%
Formaldehyde	-8%	+31%
Methylene chloride	+28%	-46%
Perchloroethylene	-52%	-46%
Trichloroethylene	-29%	-70%
Particulates		
Arsenic	-42%	-1%
Cadmium	+45%	+114%
EC ($PM_{2.5}$)	-56%	-45%
Hexavalent chromium	-73%	-29%
Lead	+1%	-21%
Nickel	-15%	-17%

Therefore, emissions trends are not necessarily consistent with the ambient concentration trends. As shown in Table 3-6, for inert species, e.g., EC, perchloroethylene, trichloroethylene, and some metals, the emissions trends and the ambient concentration trends are consistent. For some chemically active species, comparing the emissions and concentration trends are more nuanced.

Nonetheless, comparing emissions estimates with air quality measurements can provide information on whether expected emissions changes are reflected in actual ambient measurements, can be used to help calibrate emissions estimates, and may suggest where emissions inventory methods can be improved.